Space Weather Technical Forecast

Issued on Monday, 07 August 2023 at 13:17 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 Minor/Moderate storm likely from CME arrivals Days 1-2 (07-8 Aug). R1-R2 Radio blackouts with slight likely with slight chance R3 Day 1 (07 Aug).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is Moderate, with two Moderate class flares observed during the past 24 hours. The first was an M5.5 flare, peaking at 06/1840 UTC from AR3386. The second was an M2.4 flare, peaking at 07/0441 UTC, also from AR3386. This region is no longer possible to analyse as it has now rotated around the northwest limb. Despite this, further activity will likely be observable from this region through day 1 (07 Aug) with its magnetic canopy still visible in SDO imagery. There are two other regions of note, amongst the ten total sunspot regions. AR3387 in the northwest is a small region, but with an east-west parity separation line that often indicates an increased potential for flaring. AR3394 in the southeast is dominated by a large mature spot, but has seen some small spot development around its periphery, within the surrounding plage.

No Earth-directed CMEs were observed in the last 24 hours, with the most notable from the M5.5 flare off the west limb.

Solar Wind / Geomagnetic Activity: Solar winds showed the exit from a weak magnetic cloud into background slow-ambient wind. However, solar winds increased briefly to slightly elevated levels, peaking at near 450km/s around 08/0100 UTC, probably due to a passing weak feature, before winds declined back to slow-ambient levels. However, solar winds have recently increased to slightly elevated, peaking at 480km/s, with the arrival a CME at 07/1100 UTC. Density was below average, but increased to Average 5ppcc at 07/1100 UTC ahead of weak CME arrival. The total interplanetary magnetic field strength (Bt) was Weak to Moderate at 5-11nT, even with the arrival of the weak CME at 07/1100 UTC. The north-south component, (Bz) was initially weak (mostly positive), but briefly became moderate and negative (southwards), peaking -9nT around 07/0150 UTC, probably due to a weak transient feature passing by, before becoming positive (northwards). However, the Bz component became weakly negative again at 07/1100 UTC with the arrival of the first CME. Phi angle was positive (away from the Sun). Geomagnetic activity was mostly Quiet (Kp0-1), with an Unsettled (Kp 3) interval observed at 07/0000-0300 UTC.

Energetic Particles / Solar Radiation: GOES-16 high energy (greater than 10 MeV) proton flux is now below the S1 threshold, after recent activity from the M1.6 and X1.6 flares from AR3386, which has now rotated off the disc. GOES16 high energy (greater than 2MeV) electron flux was at background levels throughout. The associated 24-hour integrated fluence remained well below the Active level (1e8 integrated pfu), with 1.52e6 integrated pfu recorded at 07/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Further M-flares are likely day 1 (07 Aug) mainly from AR3386, from just over

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the northwest limb. There is a slight chance of X-flares. This risk decreases day 2 (08 Aug) onward with activity becoming mainly Low but with a chance of rising to Moderate.

Solar Wind / Geomagnetic Activity: There are a number of potential CME arrivals days 1-2 (07-08 Aug), primarily from the flaring of AR3386 on the 04-05 Aug. These are most likely to give a series of glancing impacts in the coming days, however confidence remains low and they could yet miss, or could combine or arrive concurrently to give a more significant enhancement. However, it appears one of these CMEs has just arrived at L1 (07/1100 UTC) albeit appears to be fairly weak feature. No significant coronal hole enhancements are expected in this period, with CH32/+ considered too far south. Quiet geomagnetic activity at first has the potential to become Active to G1 Minor Storm, with G2 Moderate storm intervals, with the CME arrival. There is a slight chance of G3 Strong storms, mainly early on (day 2) 08 Aug. Any enhancement is expected to ease day 3 (09 Aug) onward.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is currently below the S1 Minor Storm Level but above background due to recent enhancements on 05 and 06 Aug. Any further flaring from AR3386 has the potential to give further increases above S1, but with a decreasing risk as this region recedes around the limb. The high energy (greater than 2 MeV) electron flux is expected to remain at background at first, but with a chance of rising to Moderate or High day 3-4 (09-10 Aug) once any CME influence recedes. The associated fluence is expected to remain below Active, but with a slight chance of rising above later in the period.

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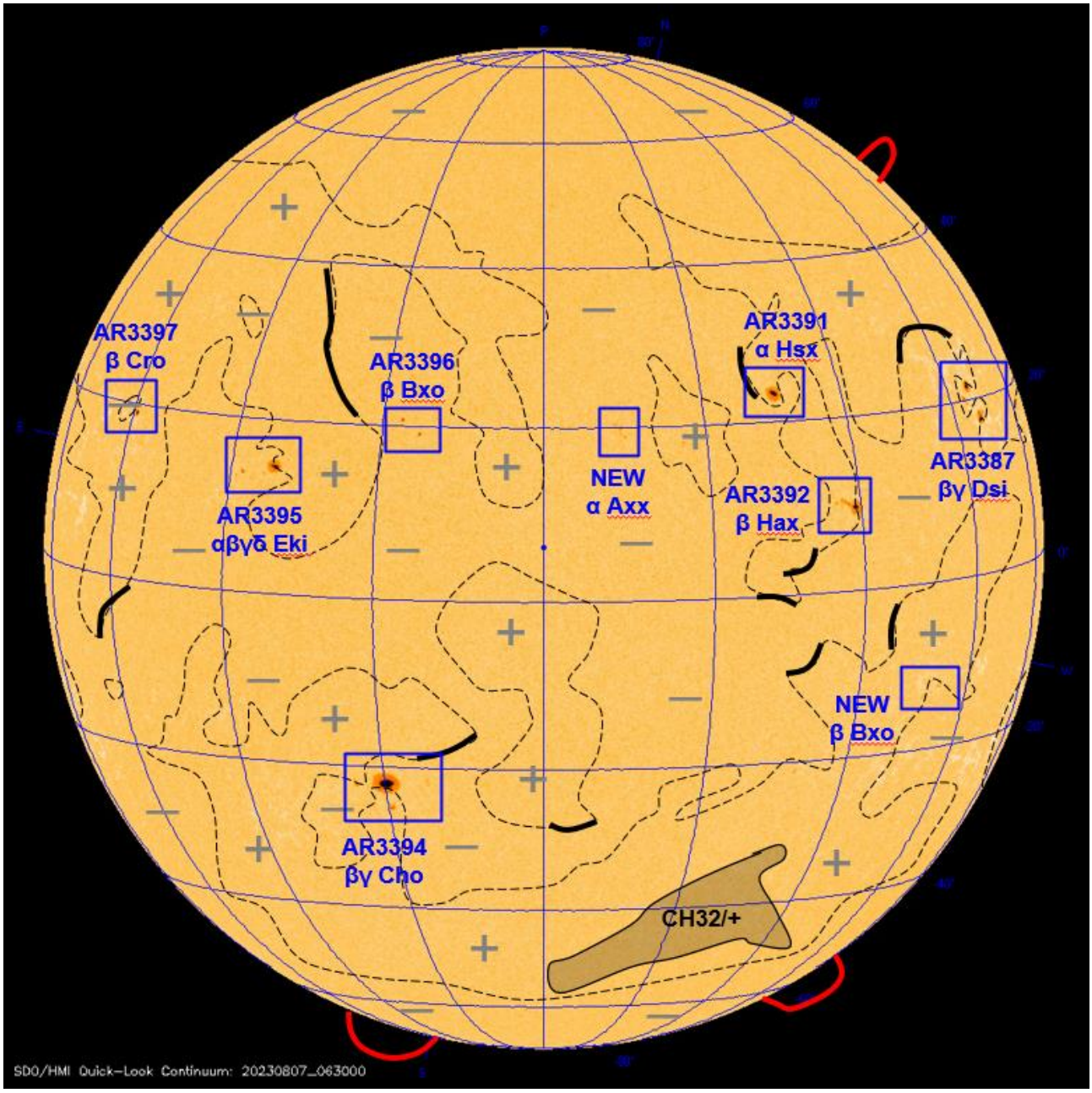
Figure 1. Solar Analysis Valid 07/0630 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:
The geomagnetic forecast is dominated by a number of CMEs that have the potential to arrive through days 1 and 2 (07 and 08 Aug).

The first is due to a complex eruption on 04 Aug, which has been modelled as two separate events, one due to the CME and another due to a nearby filament eruption. The combined CME front is expected to mostly pass ahead of Earth, but has the potential to give a glancing impact at any point on day 1, but most likely around midday. Current L1 data shows a weak CME has arrived at L1, which is probably the first of these CMEs glancing Earth.

The second potential arrival is associated with the long period M1.6 flare from AR3386 at 05/0719 UTC, and is currently expected to arrive during the second half of day 1, perhaps concurrently or very soon after the previous CME leading to an increased enhancement. However, this is also mainly passing ahead of Earth, reducing confidence in the strength of any impact.

Thirdly, the X1.6 flare, also from AR3386, at 05/2221 UTC produced a complex and broad CME that included both a fast shock and a slower bulk material section. This latter material section has been analysed as leaving at a fairly oblique angle compared to the active regions original location, also giving the potential for a glancing impact, most likely early on day 2 (08 Aug). The majority of material is again passing ahead of Earth reducing the risk of a significant impact, however with the potential for this to come after two previous arrivals, or perhaps concurrently, this gives a wide range of possible geomagnetic activity.

The only coronal hole on the disc, CH32/+ is not expected to bring a notable enhancement.
Quiet geomagnetic activity at first has a chance to increase to Active to G1 Minor Storm, with a chance of G2 Moderate storms on day 1 and into day 2 with any CME arrival. The potential combined influence of these CMEs brings the slight chance of G3 Strong Storms. Any enhanced geomagnetic activity likely easing day 3 (09 Aug) onward, to mostly Quiet later that day and day 4 (10 Aug).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	60	70	30	1
Strong	**G3**	No	10	15	1	1
Severe	**G4**	No	1	2	1	1
Extreme	**G5**	No	1	1	1	1

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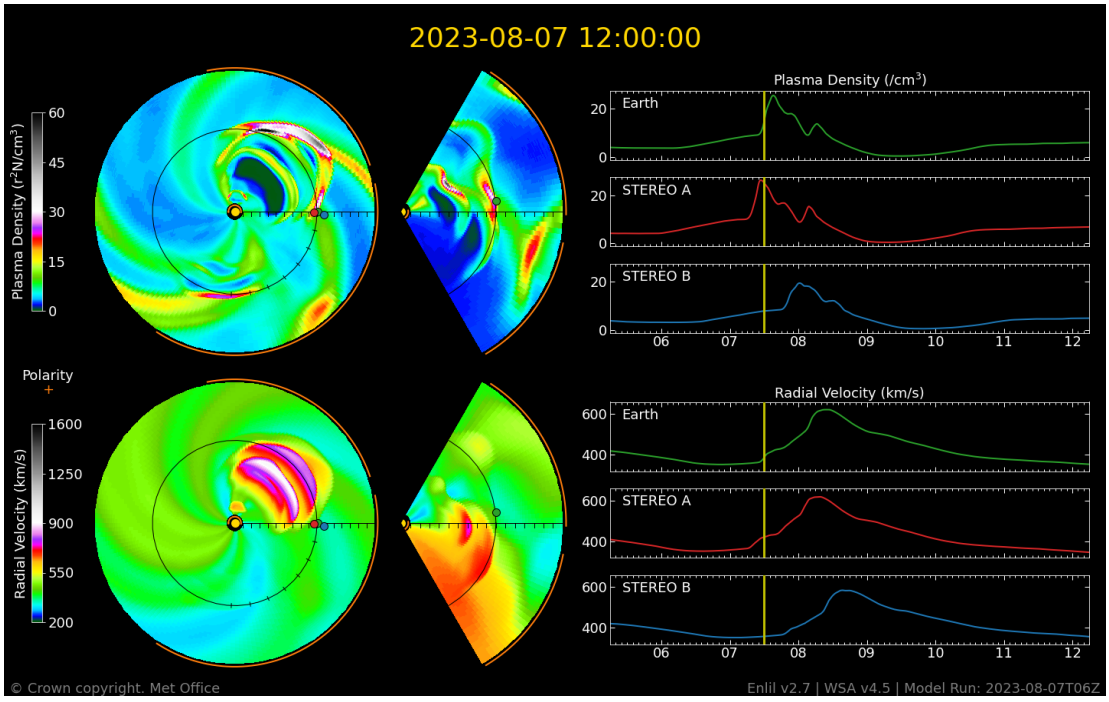
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
04/0800	Partial	M2.0 AR3386	NW	920km/s	07/0700 -6/+12hrs	Combined with CME below. Glancing impact.
04/1023	Partial	Filament near AR3386	NW	595km/s	07/0700 -6/+12hrs	Combined with CME below. Glancing impact.
05/1030	Partial	M1.6 AR3386	NW	1020km/s	07/1800 -6/+6 hrs	Glancing impact.
06/0133	Partial (full shock)	X1.6 AR3386	NW	1002km/s	08/0230 -4/+12 hrs	Glancing impact.

Figure 2: Enlil shows a sequence of glancing CMEs and ensemble showing large uncertainty.



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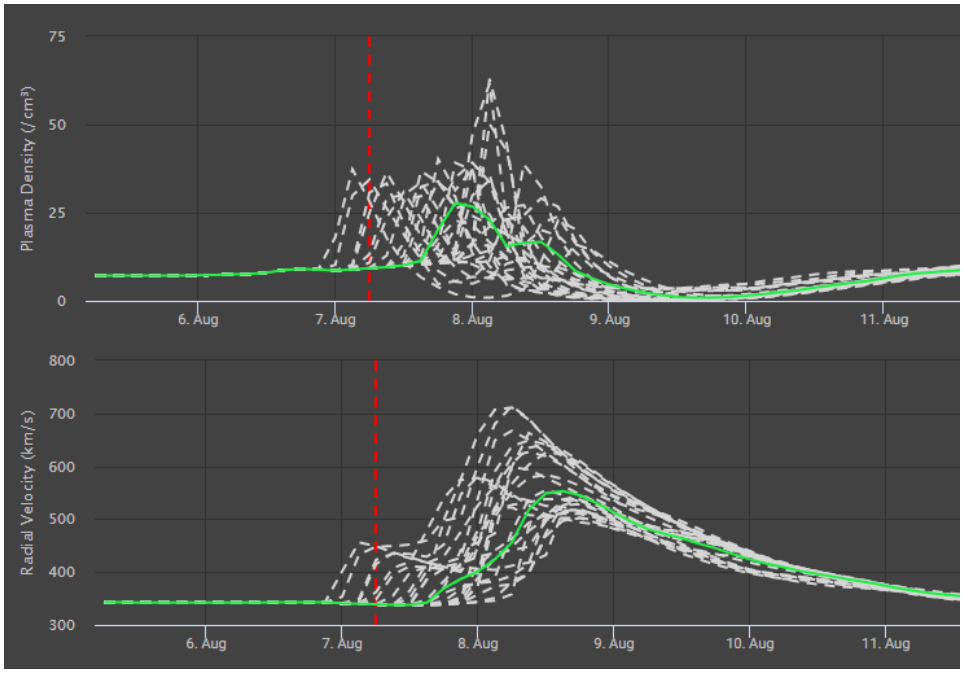

Radio Blackouts - X-Ray Flares:

Solar Activity is currently Moderate with one long duration M5.5 flare observed from AR3386, peaking at 06/1840 UTC and a second M2.4 flare, peaking at 08/0441 UTC, also from AR3386. This region was the source of a long duration X1.6 flare on 05 Aug, and has now rotated around the northwest limb. Despite now being over the horizon, there remains a chance of further observable flares from this region, mainly during the next 24 hours, before it moves further onto the far-side.

There are a total of ten regions on the disc, however the only other regions of interest are AR3387 and AR3394. AR3387 is a small region in the northwest but has an east-west orientated parity separation line that can indicate increased instability. AR3394 in the southeast is dominated by a large mature spot, but has seen some small spot development around its periphery, within the surrounding plage. Any further growth of these regions will bring an increase flare risk. Otherwise current Moderate activity, with a chance of High, due to AR3386 is expected to become mainly Low from day 2 (08 Aug) onwards, but with a chance of rising to Moderate each day.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	40	40	40
Very Active	R3 to R5 X Class	No	15	5	5	5

Figure 3: GOES16/18 X-ray flux

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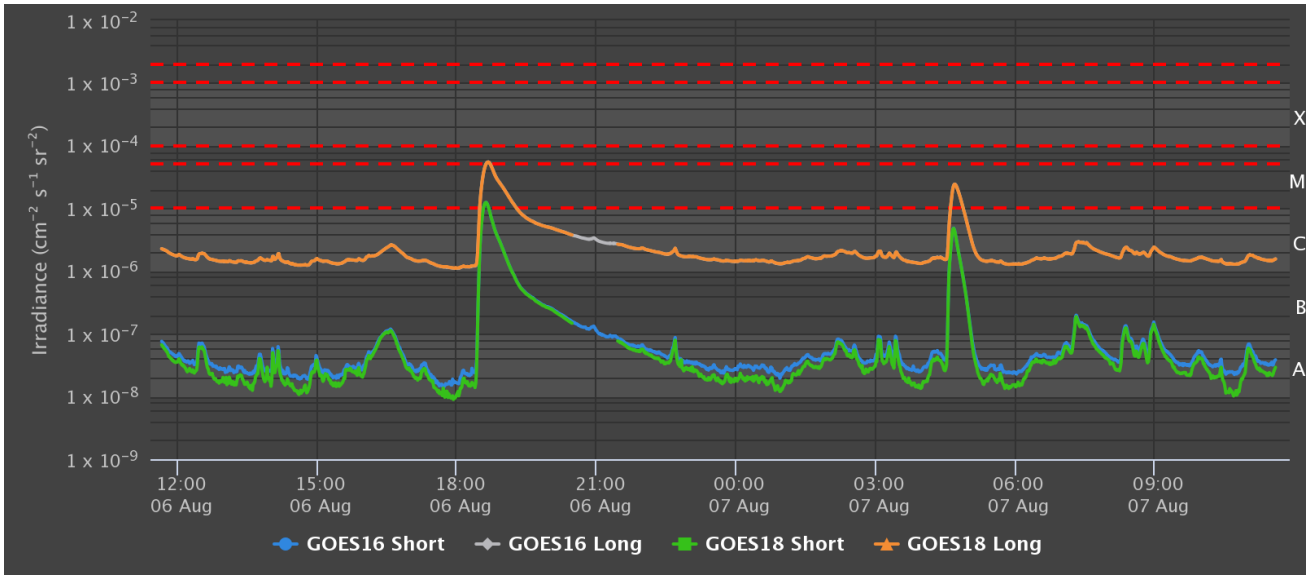

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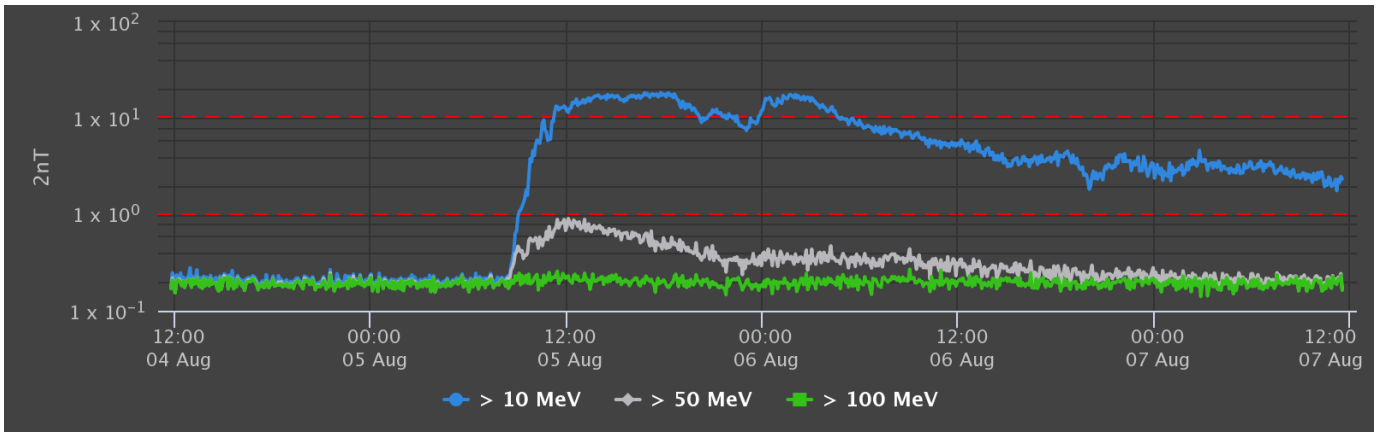
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10 MeV) proton flux observed by GOES16 is now below the S1 threshold, but remains elevated. However, enhancements back above S1 may occur from any further significant flares from AR3386, which has now rotated beyond the northwest limb. Further slight increases are possible ahead of any CME arrivals on days 1 or 2 (07 and 08 Aug) however both the arrival of these and any impact they would have on proton flux are low confidence.
By day 3 (9 Aug) AR3386 will have move sufficiently onto the far-side for the potential for proton enhancement at Earth to be much reduced, and with no other significant active regions on the Earth-facing disc, the observed proton flux is expected to decline to background.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	15	5	5
Very Active	**≥ S3 ***	No	2	2	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 4: GOES-16 >10MeV, >50 MeV and >100 MeV Proton Flux over the last 3 days.



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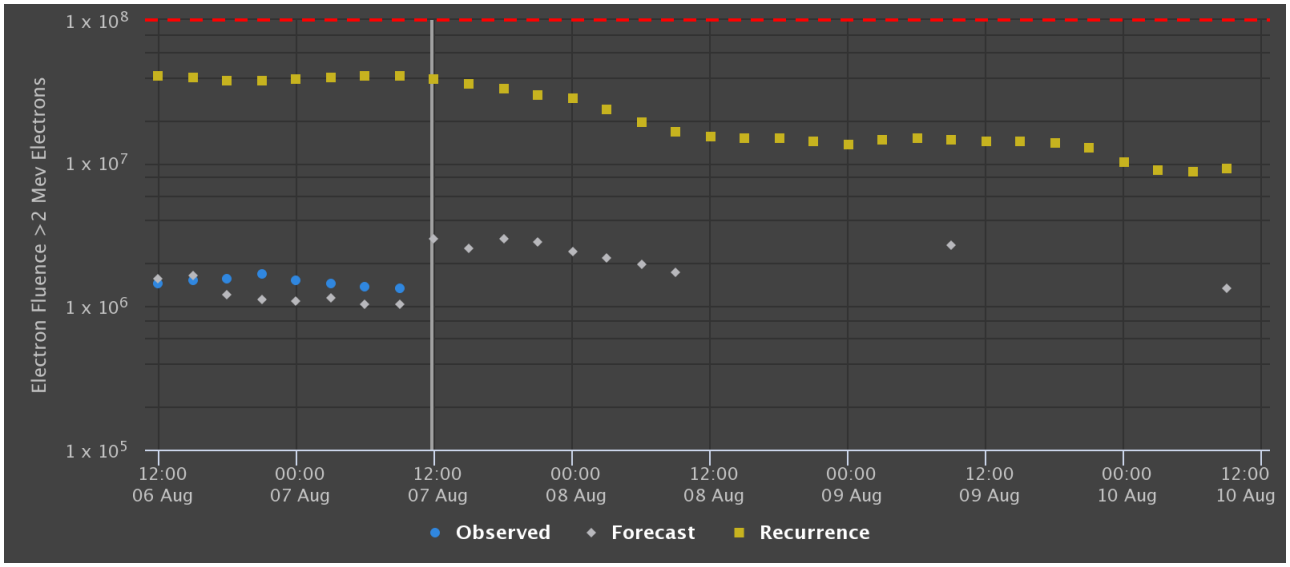
High Energy Electrons Event (≥ 2MeV):
The high energy electron flux (greater than 10 MeV) observed by GOES16 is currently at background levels, with no enhancement at GEO currently observed from recent CME enhancements. Given the likely arrival of further CMEs during day 1 and 2 (07-08 Aug), albeit mostly glancing impacts, any increased flux is likely to be contained to lower orbits until solar wind pressure eases later day 2 into day 3 (08-09 Aug). Observed flux may then increase to become Moderate, perhaps High at times, although this is Low confidence.

Overall, the associated 24 hour fluence is likely to stay below the Active level, however there is a slight chance of this rising above, day 3 (09 Aug) onward. REFM is currently giving a good guide, but is likely to be unreliable once any CME arrival occurs on day 1 (07 Aug).

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}\ sr^{-1}\ day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: MOSWOC REFM electron fluence



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